Diffraction, which forms the well-known coronas about the sun and moon, will for droplets of a certain size produce alternating red and blue rings to considerable angular distances from the luminary.[2] Recently I saw a solar corona with a set of four brilliant red rings at roughly equal intervals and interspersed with bluish rings. The larger the droplets, the smaller is the angular interval between successive rings of the same color and the smaller is the first ring around the sun or moon. Also, for any size of droplet, the angular interval between successive red rings decreases with increasing distance from the sun or moon. When the droplets are very small, as they must be in the lenticular clouds, the width of each red or blue ring is several degrees because the successive interference bands are so far apart. Thus an ordinary lenticular cloud may lie wholly within a red or blue band for very small drops. On the thin, sharp edge of the cloud where condensation has just taken place, the drops must be exceedingly small, and probably much the same size all along the edge around the cloud. For drops of this size at the distance of this cloud from the sun the diffraction band, say, is the third red one. Just inside of this cloud edge the particles have been formed for longer and have had a chance to grow to a larger size. For their size and this distance from the sun, the diffraction band, the fourth one (just beyond the third red), is blue. A little farther into the cloud the drops are still larger and are in the fourth red band for that size of drop. The central part of the cloud has still larger drops that fall in the fifth blue band. Therefore, the outer edge of the cloud has a rim of red, next comes a strip of blue and then another strip of red, while the central portion of the cloud is bluish and greenish.

The irregular intermixture of colors on the brilliant margin of a forming cumulus cloud may be explained on the same basis. The droplets just forming are not so large as those that have formed a few minutes before, and, therefore, while the angular distance from the sun may be such as to put this portion of the cloud in a red band for the droplets just formed, those a little larger even though they may be at the same angular distance from the sun are in the next blue or green band.

[2] See W. J. Humphreys, Optics of the Air, Jour. Franklin Inst., Nov., 1919, pp. 654-655.

MEASUREMENT OF WATER IN CLOUDS.

By L. F. RICHARDSON.

[Abstract from Proceedings of the Royal Society, Aug. 1, 1919, Series A, vol. 96, No. A674, pp. 19-31.]

Three types of clouds can be measured: I. Clouds into which an observer can enter. Several observers, notably Conrad and Wagner, have measured the water in clouds on mountains by drawing a measured volume of atmosphere over absorbing substances.[1] II. Clouds through which the sun's outline can be seen and which also exhibit coronae, as they often do. III. Uniform stratus, provided that some way can be found for measuring the size of the particles.

The second type of clouds has been investigated by means of a photometer which measures the variations of intensity of the sun's light in passing through cloud layers of different intensity. It has been suggested that the distance of visibility of an object through a mist is proportional to the diameter of the water particle. Conrad estimated that a terrestrial object was just visible when its intensity was about 1/77 that in clear air. This ratio of brightness of the object to its surroundings is represented by I/I_0. The observational results show that in various intensities of clouds through which the sun's disk could be seen, the volume of particles per horizontal area, the diameter of the particle, or $-2/3 \cos \zeta \log_e (I/I_0)$, is as follows; where ζ is the sun's zenith distance:

Description of cloud.	Volume of particles per horizontal area (diameter of particle).
Faintest cirrus	0.07.
Very thin cirrus	0.3, 0.3.
Ci or ci-stratus	0.04.
Very thin ci-stratus Ci-stratus, thin Ci-stratus (typical?)	0.06, 0.2, 0.8, 0.3, 0.5, 0.3, 0.8, 0.6, 0.4, 0.4, 0.8.
Ci-cumulus	0.6.
Ci-cumulus+ci-stratus	0.8, 0.9, 2.1.
Alto-cumulus	0.5.
Stratus, sun much dimmed, but still obvious at $\zeta=40°$.	2.5.
Stratus, sun's disk just visible at $\zeta=49°$	4.1.

It is pointed out that diffraction should be considered before this result can be relied upon.

In the case of heavier clouds, it is necessary to make use of the amount of transmitted light and the reflectivity of the earth's surface. In the case of certain rain clouds on the afternoon of May 24, 1918, it was found that the volume of liquid per horizontal cm.[2] of cloud amounted to 24 diameters of the cloud droplets. This, it will be noted, is in accord with the observations of thinner clouds in the table above.—*C. L. M.*

[1] The first type is discussed by Hann's Meteorology, third edition (1915), p. 306. The moisture was obtained by drawing known volumes of air over absorbing substances, such as calcium chloride or pumice stone saturated with sulphuric acid. It was found in this way that in various types of clouds on mountains the moisture content varied from 1.6 gram per cubic meter, where it was possible to see 50 meters through the cloud, to 4.5 gram per cubic meter where the radius of vision was limited to 20 or 25 meters. It was found that when the water particles are about 0.01 mm. in diameter, and the water-content of the cloud is from 1 to 2 grams per cubic meter, the number of drops is between 200 and 500 per cubic centimeter.—C. L. M.

SOME OBSERVATIONS ON A FREE-BALLOON FLIGHT MADE FROM ABERDEEN PROVING GROUND, MD., JUNE 3, 1920.

By DON MCNEAL, 2d Lieut. Meteorological Section, Signal Corps.

As a part of the course in pilots' training, a free balloon flight was made from Aberdeen Proving Ground, Md., June 3, 1920. Existing and indicated meteorological conditions on this day gave promise of anything but ideal weather for a flight of this kind. For three days preceding, this section of the country had watched the slow eastward drift of a trough of low pressure from the west and northwest, which had been attended by general rains and thunderstorms. On the morning of the 3d, the center of the trough extended from the St. Lawrence Valley southwestward over New York, Pennsylvania, West Virginia, Tennessee, and on to the Gulf.

The day opened fair, with only a few Ci.St. and A.Cu. clouds visible. These forms were moving from the west and southwest respectively. The pilot balloon observation, taken at 7:29 a. m., showed a west surface wind, veering quickly into WNW. and NW. winds, and above 8,500 feet, backing again into the west. The velocities were moderate at all levels, increasing only slightly with altitude.

The temperature mounted rapidly throughout the forenoon, and it appeared that the highest readings of the season would be recorded.

At 9:45 a. m. cumulus clouds were first observed in the northwest, drifting slowly from the WNW. At this time, the surface wind was shifting between W. and NW., with moderate velocities.

A second pilot balloon observation was made at 1:09 p. m., which indicated a backing of the wind from NE. at the surface, through N., NNW., NW., WNW., becoming W. at 6,000 feet. The velocities were low and increased only slightly with altitude, being but 17 miles per hour at 7,000 feet. At this time, large towering thunderheads could be seen moving upon the station from the NW., while others appeared to be passing some distance to the north.

The seeming assurance, which a digest of the above observations gave, of encountering all the adverse conditions incident to piloting a balloon through thunderstorms, was weighed. Also the possibility of danger from lightning was considered. However, the enthusiasm of the pilot and observers would not be denied and the balloon left the ground at 1:59 p. m.

True to the results obtained from the pilot balloon observation, we drifted off to the southward, and, with rapidly gaining altitude, moved slowly into the SSE. At the end of the first five minutes, an altitude of 2,000 feet had been reached. The temperature here had fallen from 31.3° C. at the surface, to 28.2° C. The atmosphere was very hazy to the south and southwest, while showers were observed a short distance to the north-northwest. At 2:09 p. m. an altitude of 2,340 feet had been reached and we were nearing the edge of the Chesapeake Bay. The sun was obscured and the balloon was under a heavy cumulus cloud. Difficulty was being experienced in gaining altitude, due to contraction. Thunder was first heard in the north at 2:12 p. m. At this time, it was thought best to go above the clouds to lessen the danger from lightning and, also, to endeavor to strike the westerly wind with greater velocity. The absence of sunshine, however, made this operation difficult, and required the expenditure of much ballast. At 2:14 p. m., an altitude of 2,900 feet had been reached, and we were going more nearly southeastward and approaching close to the edge of the bay. The thunder was sounding nearer and the rain appeared almost upon us. During the next several minutes, while over the bay, and with the sun hidden, constant difficulty was being met in maintaining altitude. At 2:44 p. m., we had fallen to 2,000 feet, and were over the bay and opposite the mouth of the Sassafras River. At this point, rain was heard striking the balloon. At 2:49 p. m. we were down to 1,100 feet and had moved inland south of the river. Ballast was used freely here and we began rising rapidly. The rain had stopped for a short time, but at the next observation we were in the midst of a large Cu.Nb. cloud and the rain was beating down hard. Thunder was plainly heard, although no lightning was observed. We had lost sight of the ground and were still rising rapidly. It appeared as though our position within the cloud was operating to accelerate the already rapid ascent. The vertical movements of cloud sections were readily discernible. At 3:04 p. m. we had reached 5,220 feet and appeared now to be at the edge of the cloud. Towering above us many hundred feet, we could see the great thunderheads still piling upward.

Some openings appeared above us revealing the presence of a layer of thunderstorm cirrus. The sun was now shining on the balloon, sending us still higher. The temperature while within the cloud had been down to 19.4° C. This now rose rapidly to 28.0° C., due both to direct sunlight and to that reflected from the clouds beside us. At this point our attention was attracted by moderate sized hailstones passing down past the balloon. The observation of this phenomenon would seem to agree with the theory of the formation of hailstones, which provides for their formation in the upper portions of the Cu.Nb. in preference to the theory for their formation in the squall cloud. Certainly this observation was made at a considerable distance above the level of the squall cloud; also, the temperature observations would preclude the possibility of hailstones forming at this or lower altitudes. Undoubtedly, the hail which we observed was issuing from the cloud a considerable distance above the balloon.

We were still gaining altitude at 3:09 p. m. and had encountered a moderate northwest wind which was carrying the balloon inland. About 3:22 p. m. the balloon reached the maximum altitude of the flight—8,200 feet. Shortly after this we were again within the cloud. Loud thunder was heard and it was raining hard. We now began to descend rapidly. At 3:34 p. m. we were down to 4,850 feet and still falling. Much ballast was expended in an effort to check the descent, but due to the rain and gas contraction we were unable to establish an equilibrium. We were now drifting toward a wooded ravine and a good landing did not appear possible. Our ballast was being rapidly depleted, but with only momentary relief from the unwelcome proximity to tree tops. By this time the drag rope was catching in the branches, sometimes stopping the balloon for a minute or two. From the basket the balloon now gave somewhat the appearance of a parachute. This, added to our lack of ballast, prevented our escape from this position. After each freeing of the drag rope the balloon only drifted farther down the ravine, until finally the rope became securely entangled in the top branches and held us fast. There was very little wind movement at this time and we were prevented from settling in the trees only by grasping the top branches in our hands and holding our balloon up.

We were soon rescued, however, by several farm hands, summoned from a nearby road, who cut the drag rope from the tree. We then drifted to the edge of the wooded area and valved down in the corner of a grass field, about 3 miles west-northwest of Kennedyville, Md., being an air-line distance of about 30 miles from the starting point.

Thus ended what was agreed upon by all participants as a balloon flight crowded with interesting observations and experiences.

The balloon was piloted by First Lieut. H. H. Holland, while Maj. J. C. McDonald and Second Lieuts. E. C. Cooke and Don McNeal were the observers.

EFFECT OF WEATHER ON THE AERIAL MAIL SERVICE.

Interesting notes regarding the reliability of the aerial mail service have appeared in the *Aerial Age Weekly* and the *U. S. Air Service*. In its issue of April 5, 1920, the former presents a report for the eight months preceding April. Among other points mentioned in the report is the number of forced landings on account of weather conditions. During this period there were 1,111 trips with a total of 203 forced landings, of which 47 were attributable to mechanical trouble and 154 to the weather. The latter magazine (July, 1920) reports for